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SIMULATION OF IMPULSIVELY STARTED FLOW PAST A SPHERE AND A DISC USING ITERATIVE BRINKMAN PENALIZATION

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We present an iterative Brinkman penalization scheme to enforce the no-slip condition on solid boundaries in three-dimensional flow simulations. We use a high-order particle-mesh vortex method, where the velocity field is obtained from the vorticity field by solving a Poisson equation on a Cartesian mesh as a convolution of the vorticity field with a regularized Green's function [2]. By doing this we can enforce free-space boundary conditions allowing us to consider a minimal computational domain. The Brinkman penalization method [1] is an immersed body method that allows the treatment of solids having complex geometries on a Cartesian mesh. Thereby we avoid the use of unstructured meshes that conventional flow solvers rely on. In the presented iterative scheme the penalization term is only active in the solid region and in its immediate neighborhood thus the computational costs required for the solution of the penalization problem is kept at a minimum.

We apply our method for the simulation of the impulsively started flow past a sphere at $Re = 1000$ and normal to a circular disc at $Re = 500$, respectively. Our results for the unsteady sphere flow are found to be in qualitative good agreement with results obtained by Ploumhans et. al [3] using a boundary element method. The flow is illustrated by a volume rendering of the vorticity field cf. Fig. 1. The figure shows that the flow is highly unsteady and a challenging problem for accurate analysis. Furthermore we show that the iterative scheme allows a significantly larger time step than the iterative scheme (more than a factor of 10) in the simulation of the impulsively started flow normal to a circular disc.

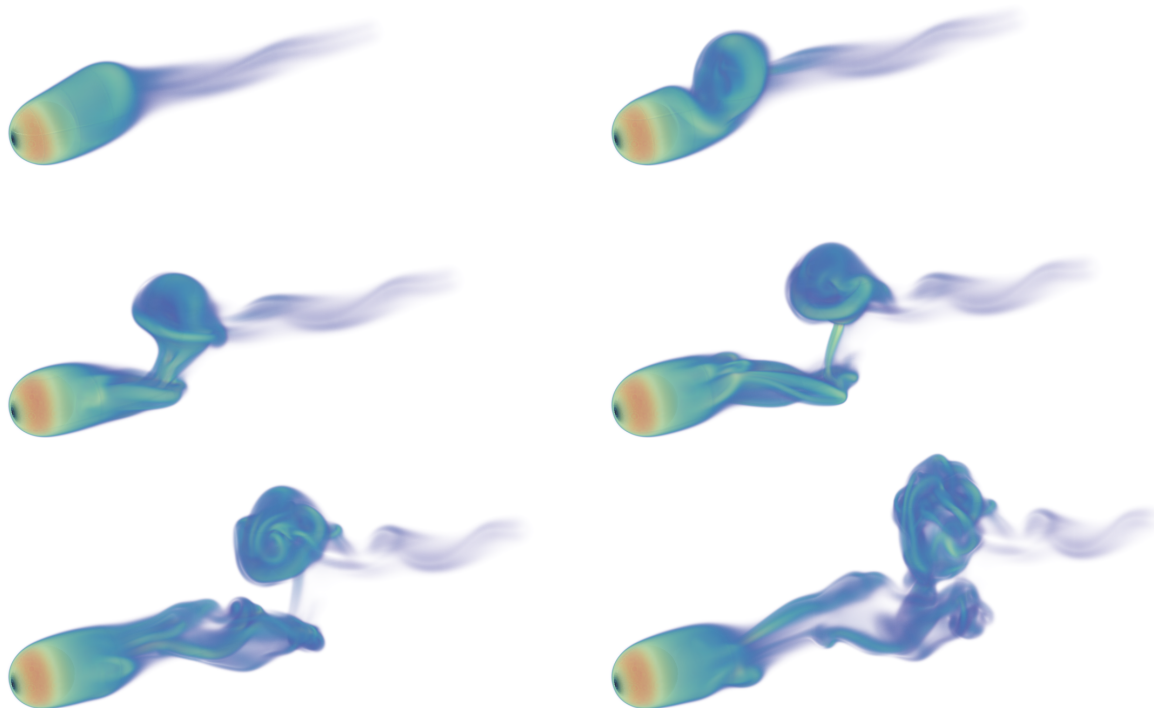


Figure 1: Impulsively started- and perturbed flow past a sphere at $Re = 1000$. Volume plot of vorticity magnitude at $tU/D = 10, 12, 14, 16, 18, 20$ (left to right, top to bottom).

REFERENCES

- [1] Philippe Angot, Charles-Henri Bruneau, and Pierre Fabrie. A penalization method to take into account obstacles in incompressible viscous flows. *Numer. Math.*, 81:497–520, 1999.
- [2] Mads Mølholm Hejlesen, Johannes Tophøj Rasmussen, Philippe Chatelain, and Jens Honoré Walther. A high order solver for the unbounded Poisson equation. *J. Comput. Phys.*, 252:458–467, 2013.
- [3] P. Ploumhans, G. S. Winckelmans, J. K. Salmon, A. Leonard, and M. S. Warren. Vortex methods for direct numerical simulation of three-dimensional bluff body flows: Applications to the sphere at $Re = 300, 500$ and 1000 . *J. Comput. Phys.*, 178:427–463, 2002.